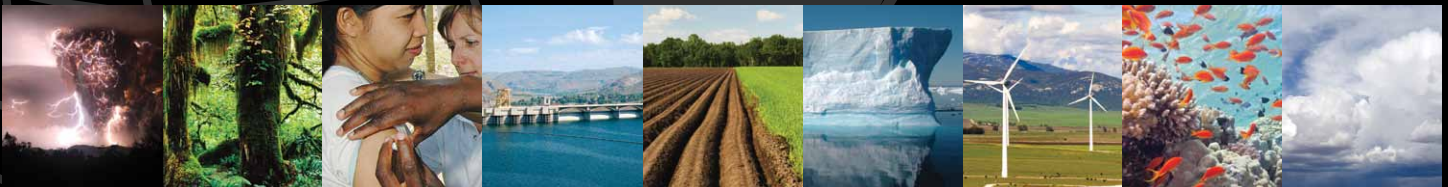


National Aeronautics and  
Space Administration



# Earth Science Serving Society

**NASA Applied Sciences Program**





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To learn more, visit: <http://AppliedSciences.NASA.gov>

The Applied Sciences Program is part of the Earth Science Division in the NASA Science Mission Directorate.



## Applications Areas

- **Disasters**
- **Ecological Forecasting**
- **Health & Air Quality**
- **Water Resources**

## Capacity Building Activities

- **DEVELOP**
- **SERVIR**
- **Gulf of Mexico Initiative**
- **Applied Remote Sensing Training**

# Overview

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## Future Applications Areas

- **Agriculture**
- **Climate**
- **Energy**
- **Oceans**
- **Weather**

NASA's Applied Sciences Program discovers and demonstrates innovative uses and practical benefits of NASA Earth science and data from NASA's Earth-observing environmental satellites. By partnering with government agencies and businesses to apply scientific findings and satellite data in their decision-making activities, the Applied Sciences Program delivers benefits of Earth science to society.

All Program activities support goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning. By working with partners—and continuing to build new collaborations—the Applied Sciences Program is identifying ideas and priorities for new applications.

Applied Sciences supports both applied research and targeted decision-support projects in nine areas of national priority. The Program currently has formal efforts in four Applications Areas: Disasters, Ecological Forecasting, Health & Air Quality, and Water Resources. The Program supports ad hoc activities in five other areas, seeking opportunities to expand and develop them into formal applications areas in the future. The diverse portfolio of projects delivers results and societal benefits through applying Earth observations to improve early warning systems, water management, natural hazard response, disease tracking, adaptation to climate risks, and many other important topics.

The Applied Sciences Program has four Capacity Building activities: DEVELOP, SERVIR, Gulf of Mexico Initiative, and Applied Remote Sensing Training. These activities sponsor specific projects that improve the skills and capabilities of decision makers, community leaders, and resource managers in the United States and abroad, especially in developing countries, related to accessing and applying Earth observations.

Applied Sciences also looks to identify potential applications early in the planning for future satellite missions. The Program encourages organizations to become involved in satellite mission planning, anticipate potential applications, contribute to design discussions, and be prepared to use the data soon after launch.

We invite you to become involved in the Applied Sciences Program and apply Earth observations in your activities.



# Disasters

## Applications Area

The Disasters Applications Area promotes the use of Earth observations and tools in the management of natural and technological disasters. Public and private organizations apply remote sensing observations, modeling, and analysis capabilities to improve disaster preparations, response, and recovery. The Disasters area supports projects to enhance management practices and disaster reduction across disaster types, including earthquakes, floods, landslides, volcanoes and wildland fires.

Disasters applications and applied research on natural hazards support emergency preparedness leaders in developing mitigation approaches, such as early warning systems, and providing information and maps to disaster response and recovery teams.

### Tracking Volcanic Ash for Aviation Safety

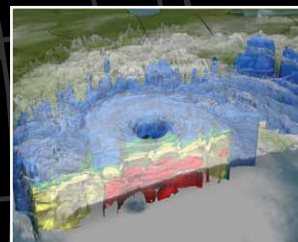
Large volcanic eruptions can eject ash to heights at which commercial aircraft normally fly. The ash can damage airplane engines and fuselages, making it necessary to reroute or cancel flights to protect aircraft and passenger safety.

The *Aura* satellite measures ash aerosols and sulfur dioxide, which serve as reliable markers for volcanic ash clouds. Over several years, Applied Sciences worked with the National Oceanic and Atmospheric Administration (NOAA) and the Federal Aviation Administration (FAA) to apply *Aura* data at the two U.S.-based Volcanic Ash Advisory Centers (VAAC) and enhance their warnings.

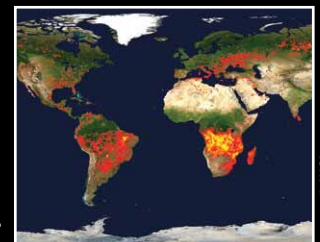
When Iceland's Eyjafjallajökull volcano erupted in 2010, volcanic ash spread across the skies over Europe, canceling thousands of flights and leaving passengers stranded. NASA was able to quickly support requests through NOAA and FAA to provide ash-plume reports to the Volcanic Ash Advisory Center in London. European officials used the *Aura* products in their determinations of which airspace to open and when. Today, VAACs continue to receive information on volcanic ash and sulfur dioxide plumes, giving critical updates to the aviation industry and ensuring safe airspace.



*Aqua* has six instruments monitoring Earth's oceans, clouds, land, ice and snow cover, atmosphere, and vegetation.



The *TRMM* satellite collects data used to understand the internal structure of hurricanes and aid in landfall predictions.



The United Nations Global Fire Information Management System sends fire alerts to natural resource managers within hours of fire detections by *Aqua* and *Terra*.







# Ecological Forecasting

## Applications Area

The Ecological Forecasting Applications Area promotes the use of Earth observations and Earth science models in applications that shed light on environmental changes that affect ecosystems and their living elements. The forecasting tools and capabilities developed with Applied Sciences' support assist land use managers, fisheries, and other decision makers in the areas of conservation biology, natural resource management, and sustainable development. The applications and tools aid officials in assessing alternative approaches and designing effective management strategies.

### Managing River Temperatures and Ecosystems

Water managers make decisions that balance the short- and long-term needs of urban communities, wildlife, agriculture, energy, and other uses. High demand for limited water supplies can result in altered in-stream flows and water temperatures. These alterations can create problems for several fish, including endangered salmonid species, as water temperature is critical to their survival. To develop effective water planning strategies, managers need timely and accurate information on a variety of environmental conditions. They have used monthly river temperature averages in their decisions, yet these monthly data do not always account for fine-scale temperature changes affecting fish species.

An Applied Sciences project examined the use of remote sensing data and Earth science models to show fine-scale river temperatures along the Sacramento River. The NASA-NOAA project team applied the NASA Terrestrial Observation and Prediction System to integrate satellite observations with ecological and physical models to predict river temperatures in real time with high accuracy. The team used data from the MODIS sensor on board the *Terra* and *Aqua* satellites to drive the modeling framework.

The project was successful in showing finer-scale temperature fluctuations that were not possible before. Water temperature readings are available every 15 minutes for essentially all points along the river, and the information can be used in fish mortality estimates. Water managers can forecast temperatures up to 72 hours in advance for use in the management of water releases to minimize potential impacts to fish species.



image credit: NASA

The *Terra* satellite has five sensors gathering data on Earth's land, atmosphere, oceans, and biological productivity as well as the interaction among them.



image credit: NASA

*Landsat* images, like this one of a mangrove forest in Malaysia, support assessments of changes in land cover by resource managers and land-use planners.

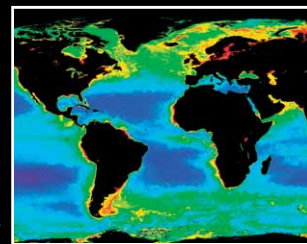


image credit: NASA

Ocean color (shown) and ocean surface temperature data from *Aqua*/MODIS are factors used in fisheries assessments and the management of marine ecosystems.









# Health & Air Quality

## Applications Area

NASA's Health & Air Quality Applications Area supports the use of Earth observations in air quality management and public health, particularly regarding infectious diseases and environmental health issues. The Application Area addresses issues of toxic and pathogenic exposure and health-related hazards to aid in risk characterization and mitigation. The area promotes uses of Earth observing data and models for improved air quality forecasts, implementation of air quality standards, and planning and compliance for economic and human welfare. The Health & Air Quality Applications Area addresses effects of climate change on public health and air quality to support managers and policy makers.

### Using Earth Observations for Malaria Early Warnings

Earth observations can provide information on environmental conditions associated with outbreaks of some infectious diseases, such as malaria and Rift Valley Fever. Malaria infects hundreds of millions people every year and claims countless lives. In areas where malaria is endemic, health officials often have limited resources to direct preventative measures and protect vulnerable populations.

Applied Sciences sponsored a project to apply *TRMM*, *Aqua*, *Landsat*, and other observations into models of mosquito activity and develop estimates of malaria vectorial capacity (efficiency of disease transmission). The project used satellite-based rainfall, land surface temperature, vegetation cover, and other environmental data to identify specific regions where outbreaks were likely to occur.

Today, a Malaria Early Warning System maintained by the Earth Institute provides 10-day precipitation estimates to malaria control planners in Africa. A U.S. Geological Survey (USGS)-U.S. Agency for International Development (USAID) system provides maps of rainfall anomalies and vectorial capacity in African zones with malaria epidemic potential. The systems enable the identification of areas with unusually high rainfall as candidates for malaria outbreaks. Information on high-risk areas can provide warnings of potential epidemics many months in advance, allowing health officials to allocate staff and resources to areas most likely at risk for an outbreak.



image credit: NASA

*Aqua's* four instruments provide data on Earth's atmosphere, including information on the ozone layer, aerosols, trace gases, and air quality.

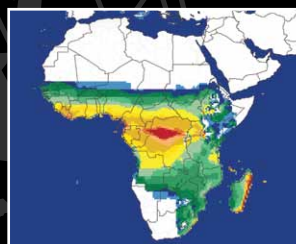


image credit: The International Research Institute

This map shows the number of months suitable for malaria transmission, based on rainfall, temperature, and humidity. Warmer colors indicate a greater number of months.



image credit: NASA

EPA's AIRNow combines aerosol data from ground monitors (points) and from MODIS on *Aqua* and *Terra* (areas) to give regional air quality conditions.









# Water Resources

## Applications Area

The Water Resources Applications Area promotes the routine use of Earth observing data and tools in water management for sustainable use. Water Resources focuses on themes of drought, stream flow, flood forecasting, water supply and irrigation, water quality, and climate impacts on water resources. The program addresses water in all forms—from lakes, rivers, streams, and seas to snow and groundwater.

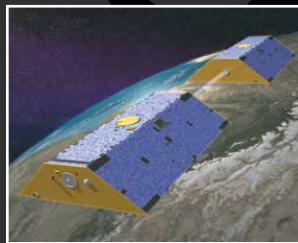
Public and private organizations can apply Earth observations in assessments of water availability and water quality. The data can aid decisions for effective water management. Some states have used NASA satellite data to assess snowmelt, which provides water for citizens, agriculture, and hydroelectric power generation. In addition, U.S. forces in Afghanistan have used NASA snowmelt data to better understand water supply and availability in that region of the world.

### Monitoring Drought Using Satellite Observations

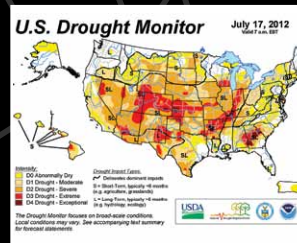
The National Drought Mitigation Center produces the U.S. Drought Monitor and official drought maps on a weekly basis. Managers and government officials use maps from this premier drought monitoring tool to better manage limited water supplies and distribute drought aid where it is needed most.

The U.S. Drought Monitor uses drought indicators for soil moisture and groundwater developed under an Applied Sciences project. The indicators use Earth observations from the U.S.-German *Gravity Recovery and Climate Experiment (GRACE)* satellites. *GRACE* detects very small variations in Earth's gravitational field. The variations are used to determine changes in the total amount of water stored both on top of and below the land surface (e.g., snow, surface waters, and groundwater), which can aid in better classification of drought severity.

The project combined the *GRACE* data with rainfall, temperature, other measurements, and numerical modeling to create a soil and groundwater record, addressing the need for accurate information on deep water storage conditions. The officials who produce the U.S. Drought Monitor's weekly maps use this valuable information to gauge the impact of long episodes of wet or dry weather.



The *GRACE* satellites map variations in Earth's gravity field that can reveal changes in levels of large, underground aquifers.



The U.S. Drought Monitor gives weekly maps of drought conditions, using *GRACE* data on ground water storage and root zone soil moisture as input.



*OSTM/Jason-2* collects data on ocean surface heights and can track levels of larger inland lakes and reservoirs, aiding crop production forecasts.







# Agriculture

## Future Applications Area

The Agriculture Applications Area will promote the use of Earth observations to enhance agriculture management and policy on topics of risk assessment, forecasting, and global food security. The use of these data can help planners adapt to droughts, floods, invasive species, and the impacts of a changing climate on agriculture both domestically and abroad. This area will use observations and models to support agricultural productivity and yield forecasts, examine conservation effects, and assess management alternatives.

Applied Sciences previously supported an Agriculture Applications Area and sponsored numerous projects. The Program plans to restore this area as opportunities allow.

### Optimizing Agricultural Irrigation

Irrigation is often a necessary step toward growing a healthy crop for harvest, especially in the drier western states. Determining how much and when to irrigate can be a complicated and costly decision. Research showed that incorporating information on weather conditions and crop growth stage into irrigation scheduling practices could improve yields while reducing the total applied irrigation on average.

To map and forecast irrigation demand, the California Department of Water Resources and NASA partnered to apply *Terra*, *Landsat*, and *Aqua* data to extend the capabilities of the California Irrigation Management Information System (CIMIS). CIMIS provides publicly-available information useful in estimating crop water use for irrigation scheduling. Agricultural growers, landscape managers, and water managers use CIMIS for assessing crop water needs, allowing for ways to improve irrigation management.

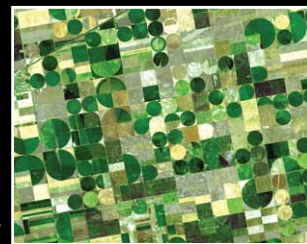
The Applied Sciences project combined satellite observations of crop canopy conditions with CIMIS agricultural weather conditions to estimate crop water needs for each field. This combination provided a new source of information that can be used by growers to account for optimal irrigation rates when scheduling irrigation. The enhanced information products can map crop water requirements over 15 million acres of farmland in California's Central Valley. Thus, the project delivered ways to map key indicators of agricultural irrigation demand across the entire Central Valley at the scale of individual fields daily.



With imagery of Earth's continental and coastal landscapes, *Landsat 7* supports applications in agriculture, cartography, geology, forestry, and regional planning.



This image of Lake Naivasha, Kenya, from *Terra* shows the scope of the agriculture industry, specifically flowers for export, in that region.



*Terra*'s ASTER instrument produced this image of agricultural plots, irrigated by water from the Ogallala Aquifer, in southwestern Kansas.







# Climate

## Future Applications Area

The Climate Application Area will promote uses of Earth observations and Earth science models to support assessments, policy analyses, and implementation approaches that organizations will consider in their planning and response to climate change. The Climate Applications area will address adaptation and mitigation issues and the specific topic of carbon management. This area will focus on applications of Earth observations to assess climate policy alternatives and to track progress toward climate policy objectives.

Applied Sciences previously had a Climate Applications Area and supported numerous projects. The Program looks to renew this area as opportunities allow.

### Supporting Forest Management Plans

Forests can play an important role in offsetting carbon emissions as they absorb carbon dioxide from the atmosphere. Yet forests do not solely remove carbon. Some release carbon through events like wildland fires, insect infestations, and timber harvests. To know exactly how much carbon a forest can absorb—and therefore ways to best manage a forest—it's important to understand the dynamics in forest ecosystems over time.

An Applied Sciences project focused on applications of Earth observations to support forest carbon management practices. The project used images from *Landsat* and the Forest Inventory and Analysis reports of the U.S. Forest Service to examine changes in forest cover in Oregon forests. The project integrated landscape modeling, satellite observations, vegetation mapping, and computer simulation for an innovative approach to carbon assessment. The project helped the Oregon Roundtable on Sustainable Forests to assess the feasibility of their forest management plans. In addition, the Oregon Department of Forestry gained insight into the annual flux of carbon through their forests.

With applications like this one, managers and policy makers use Earth observations to integrate environmental, economical and social considerations into land management decisions. Earth observations also provide effective visuals of changes in forest coverage. These visuals help forest managers and the general public to understand changes occurring over time in and around their communities.



image credit: NASA

*OSTM/Jason-2* measures ocean surface heights, providing information on global sea level, speed and direction of ocean currents, and heat stored in the ocean.

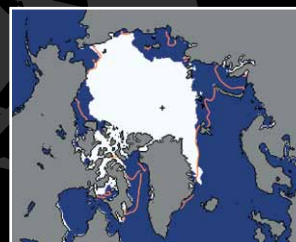


image credit: National Snow and Ice Data Center

Satellite microwave sensors measure the extent of Arctic sea ice. This image shows the extent for June 2012; the magenta line is the 1979-2000 median extent for June.



image credit: NASA

*Terra's* ASTER sensor captured this false-color image showing deforestation in Brazil. Red areas indicate rain forests, and brown areas indicate cleared land.







The Energy Applications Area will enable the use of Earth observations and Earth science models to improve the locating, planning, and harvesting of renewable energy sources such as wind, geothermal, and solar. The area will focus on topics of energy efficiency, load forecasting, energy source distribution, building design, and energy assessments. Public and private organizations can use Earth observations and models to improve the use of renewable sources in meeting energy needs and policy objectives.

Applied Sciences previously included an Energy Applications Area. The Program funded several projects related to energy applications, which will help the Program prepare for and restart this area in the future.

### Locating Productive Sites for Wind Power

Selecting optimal sites to construct a wind farm is key to determining the long-term efficiency and profitability of a wind energy venture. The process of site location can take significant analysis and a large financial investment. Applied Sciences sponsored a project with the National Center for Atmospheric Research (NCAR) to assess the use of Earth observations in reducing the time and expense needed to evaluate and map optimal areas for harnessing wind power.

The project developed an accurate and economical wind assessment model using NASA Earth science capabilities. The model incorporated the NASA Mirador data access tool, innovative statistical techniques, and data from MERRA, which is NASA's three-dimensional global record of weather since 1979. Using these and an NCAR weather analysis system, this project enabled wind farm developers to incorporate NASA-NCAR analysis into their own decision making.

With this information, a development team can use a sample of days to build a 30-year analysis of wind conditions at specific locations. The project's sampling techniques can provide an accurate, reliable, and rapid estimate of wind power production at a location with significantly reduced simulations and analysis expenses. The techniques support lower development costs and the Nation's use of renewable energy sources.

## Energy

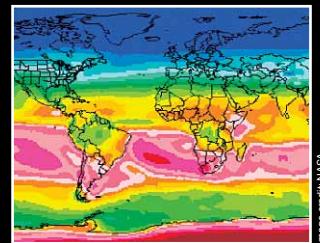
### Future Applications Area



*Suomi NPP* collects remotely-sensed land, ocean, atmosphere, and solar radiation data, continuing key measurements from *Terra*, *Aqua*, and *Aura*.



Earth observations can help assess amounts of water in snow packs, which can aid in the management of hydropower generating facilities.



Maps of solar radiation at Earth's surface (like this from the CERES sensor on *Aqua*, *Terra* and *Suomi NPP*) support managers in locating and designing solar energy systems.







The Applied Sciences Oceans Applications Area will promote the use of Earth science models and Earth observing data for issues affecting ocean and coastal regions. The area will develop Earth science applications to support resource management, trade and navigation, assessment of options to sea level change, and emergency management and response. The Oceans Applications Area will focus on enhancing policy, business, and management decisions related to coastal zones, nearshore environments, marine and open ocean activities, oceanic islands, and reefs and estuaries.

Applied Sciences has sponsored some projects related to ocean and coastal applications, which will help the Program prepare for a future Oceans Applications Area.

### Navigating Icy Paths

As Arctic sea ice melts, new shipping routes once inaccessible are becoming navigable. Yet ice flows still exist in the Arctic, leading to dangerous situations for ship, crew, and cargo. The Polar Ice Prediction System provides short-term sea ice forecasts, but this system has a grid resolution of approximately 27 kilometers. The Arctic Cap Nowcast/Forecast System (ACNFS) has improved upon the Polar Ice Prediction System's resolution, yet more detailed sea ice information could create even higher-resolution datasets.

NASA Applied Sciences supported a project to do just that. By using Earth observing data from the *Aqua* satellite, the highest resolution and most accurate dataset to date was developed and implemented into the ACNFS sea ice forecasts for testing. Initial results showed that the ACNFS, using the merged NASA data, improved forecasts as much as 54 percent with a regional improvement of 36 percent on average. Significant improvements in accurately forecasting sea ice can save valuable time and, most importantly, support safety in navigating the waters of the Arctic.

## Oceans

### Future Applications Area

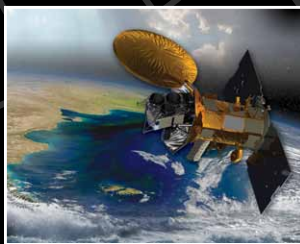


image credit: NASA

*Aquarius* provides global observations of salinity (concentration of dissolved salt) at the ocean surface, a key tracer for understanding ocean circulation and global freshwater balance.



image credit: USGS/NASA

Phytoplankton blooms, seen as green swirls in this *Landsat* image of Gotland island in the Baltic Sea, occur when deep currents bring nutrients up to sunlit surface waters.

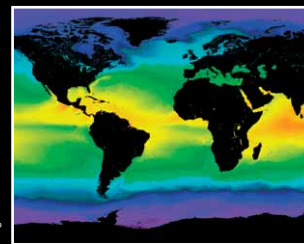


image credit: NASA

Sea surface temperature data, shown in this *Aqua*/MODIS image, are used in many applications, such as weather forecasts and fisheries management.







# Weather

## Future Applications Area

The Weather Applications Area will enable the use of Earth observing data and tools to support specific weather-affected economic interests and enhance the global mobility of people and goods. The area will focus particularly on transportation, including aviation weather applications to support the Next Generation Air Transportation System, or NextGen. The Weather Applications Area will address issues related to convective weather, which produces thunderstorms, high winds, heavy precipitation, hail, and lightning—these conditions can lead to weather-related travel and supply chain delays, economic impacts, and human hazards.

Applied Sciences previously supported a Weather Applications Area and sponsored numerous projects. The Program looks to resume this area as opportunities allow.

### Predicting Turbulence with Earth Observations

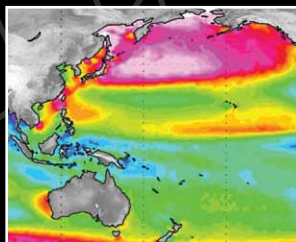
Turbulence is the primary cause of serious injury to passengers and flight crews aboard commercial passenger aircraft. Accurate predictions of where and when turbulent skies are likely to occur increases the efficiency of the National Airspace System and improve air travel safety overall.

To address this, Applied Sciences supported a project with NCAR and the University of Wisconsin-Madison to apply NASA Earth observing data to develop and enhance a new Global Graphical Turbulence forecast tool.

The project used data from the *Aqua*, *QuikSCAT*, and *Aura* satellites to increase the accuracy of turbulent air space predictions and aid the World Area Forecast System, which issues alerts and weather charts to the worldwide aviation industry. The use and application of NASA's Earth observing data by the World Area Forecast System forecasters can improve the safety and efficiency of air travel.



*TRMM*, a joint mission between NASA and the Japanese Aerospace Exploration Agency, monitors tropical rainfall.



*QuikSCAT* data on ocean winds enhance the accuracy of weather forecasts and show wind power density over global oceans.



*TRMM* collected data that supported assessments of tornadic thunderstorms over the eastern United States in early spring of 2011.







DEVELOP is a national training and development program in which young professionals gain hands-on experience with satellite remote sensing and apply Earth observations to real-world issues facing state and local governments. Participants work on specific projects and deliver and communicate their results to broad audiences and leaders in government, academia, and industry. Through DEVELOP, young professionals extend the benefits of NASA Earth observations and models to the public.

The program fosters a high-quality corps of early-career professionals, cultivating advanced skills in Earth science applications and an understanding of science in decision making. DEVELOP expands the network of organizations and individuals benefiting from Earth observations and promotes a high-tech workforce.

### Enhancing Fire Risk Maps and Monitoring

In 2011 fires burned nearly 4 million acres of land across Texas. The Texas Forest Service is responsible for directing all matters pertaining to forestry within the state, and it was interested in the capabilities of NASA Earth observations to enhance and assist in their fire monitoring during and after wildfire events. A four-person DEVELOP team worked with the Texas Forest Service to apply data from *Terra*, *Aqua*, and *Landsat* satellites to assess the impacts of the fires.

The DEVELOP team used burn-scar imagery and calculated various spectral indices to assess the surface vegetation, impact of drought, and magnitude of ecological change caused by the fires. The team combined these separate analysis techniques to generate a composite fire risk map and a time-lapse representation of the changing conditions of surface water resources during the duration of the fires. This information provided the Texas Forest Service with a method for timely and cost-effective assistance in fire management.

<http://develop.larc.nasa.gov/>

## DEVELOP

### Capacity Building Activity



Image credit: NASA

*CloudSat* provides information on the structure and composition of clouds under all weather conditions using an advanced cloud-profiling radar.



Photo credit: Science Systems and Applications, Inc.

A DEVELOP team and its adviser collect field samples to compare with satellite measurements in an application project on wetlands restoration.

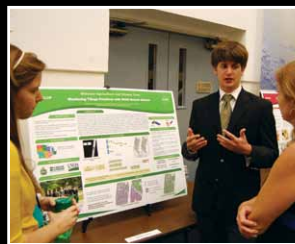


Photo credit: NASA

A DEVELOP intern presents the results of his team's agriculture application project during a conference poster session.







# SERVIR

## Capacity Building Activity

SERVIR is a joint NASA-USAID initiative that integrates satellite observations, ground-based data, and forecast models to help developing nations monitor, forecast, and respond to environmental changes. SERVIR has regional hubs in East Africa and the Hindu Kush Himalaya region as well as a network affiliate in Central America. Additional hubs are expected. Endorsed by governments in these regions, SERVIR places a strong emphasis on partnerships to provide searchable and viewable Earth observations, measurements, animations, and analysis.

Using Earth observing satellite data, SERVIR enables managers, educators, scientists, media outlets, and policy implementers in the regions to respond better to a range of issues including disaster response, air quality, biodiversity conservation, climate change, water resources, health, and agricultural development.

### Assessing Streamflow and Anticipating Floods

Floods are among the most catastrophic natural disasters in Africa. SERVIR-East Africa developed a system to help hydrologists from water ministries in the region predict where floods might occur. The system was built upon a modeling tool called CREST, or Coupled Routing and Excess Storage. CREST integrates data from *TRMM* as well as local rainfall information. SERVIR-East Africa trained hydrologists from Burundi, Ethiopia, Kenya, Malawi, Mauritius, Namibia, Swaziland, Rwanda, Tanzania, Uganda, and Zambia as well as ones from Bhutan and Nepal to use the system in assessing streamflow.

In addition to rainfall, CREST takes into account evaporation, transpiration, soil porosity, the amount of moisture in the ground, and land shape/elevation to produce streamflow forecasts up to three days in advance. Combined with historical or current data, this information helps water resource managers better anticipate where flooding could occur and issue warnings when flooding is imminent. Streamflow information also supports farming practices and gives early warnings of agricultural production deficits, which help officials plan for and respond to food emergencies.

<http://www.servirglobal.net/>



image credit: NASA

EO-1 is an advanced land-imaging mission and provides multispectral and hyperspectral images of Earth's surface.



image credit: CIMOD

SERVIR-Himalaya supported a climate symposium in Bhutan for government officials, scientists, managers, youth, and media involving applications of Earth observations.



image credit: NASA

SERVIR-East Africa used this EO-1 image of the Nzoia River basin to create a baseline of this frequently flooded area for analysis.









# Gulf of Mexico Initiative

## Capacity Building Activity

The Gulf of Mexico Initiative supports the Gulf region in applying Earth observations to address coastal management issues. Formed after the devastating Hurricanes Katrina and Rita, the Gulf of Mexico Initiative focuses on regional priorities defined by the Gulf of Mexico Alliance, a collaboration of Alabama, Florida, Louisiana, Mississippi, Texas, and 13 federal agencies, to enhance the ecological and economic health of the Gulf region.

The Gulf of Mexico Initiative promotes the use of Earth observing satellites to provide information that helps local, state, and federal leaders of the Gulf make informed decisions, establish policies, and respond to crises in their region.

### Detecting Oceanic Oil Spills

Six months before the Deepwater Horizon oil spill in the Gulf of Mexico, an Applied Sciences GOMI project began developing techniques to use Earth observing satellite data to improve the detection of oil spills in the Gulf. This project created automated and interactive techniques to generate oil slick maps using data from Earth observing satellites, including *Terra*, *Aqua*, *CALIPSO*, *Envisat*, *ERS-2*, *RADARSAT*, and *ALOS*. The team included researchers and applications specialists from the Naval Research Laboratory, NOAA, and NASA.

Working with Alabama A&M University, the team also demonstrated that oil spill aging and breakup can be monitored in real time and that methods of oil spill detection and characterization can be automated. Utilizing NASA Earth science resources led to a clearer picture of what was happening in the Gulf of Mexico during the spill and can be used in the event of future oil spill incidents. The team's techniques are expected to transition to NOAA to enhance the activities of NOAA's Emergency Response Division, which provides maps for emergency response activities.

<http://www.coastal.ssc.nasa.gov/>



Photo credit: NASA

NASA's Global Hawk is a robotic plane for collecting Earth science data. It can fly autonomously to altitudes above 60,000 feet for as long as 30 hours.



Image credit: NASA

Marshes and mudflats of the Mississippi River Delta, shown in this *Terra* image, protect the mainland from storm surges and provide a home for fish and wildlife.

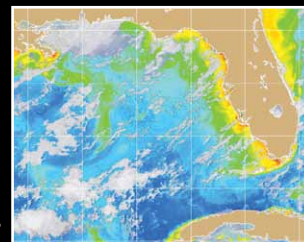


Image credit: NOAA

NOAA's Harmful Algal Bloom Bulletin uses satellite data, such as MODIS chlorophyll, and other observations to provide information on locations of blooms in the Gulf of Mexico.









# Applied Remote Sensing Training

## Capacity Building Activity

The Applied Sciences Program conducts professional-level training focused on building skills and familiarity in accessing and using Earth observations data. By providing hands-on, computer-based training, the Program is raising awareness of remote sensing and the value of NASA's free and publicly available Earth science data.

The Applied Remote Sensing Training activity hosts in-person and online workshops and sessions throughout the year. Training participants learn how to access, interpret, and apply NASA remote sensing data at regional and worldwide scales, using interactive case studies to build familiarity and skills. Applied Sciences currently conducts trainings in air quality and water resources, and it expects to add trainings in additional topics.

### Growing the Seeds of Experience

Applied Sciences plays an active role in capacity building activities, including Earth observations training, to enable people to actively use, teach, and expand the applications of NASA Earth observing data and models. Atmospheric modeler Scott Beaver with the Bay Area Air Quality Management District is a true example of the far-reaching effects of the capacity building investments.

In 2009, Beaver attended an Applied Sciences training entitled "Remote Sensing Data Usage in Air Quality Assessments." Within a year, he was teaching that same class. From his experience, Beaver was able to actively incorporate *Terra* and *Aqua* imagery, *CALIPSO* aerosol data, and *Aura* trace gas measurements into applications that the Bay Area Air Quality Management District can use when developing emissions reduction programs. His students have learned how to apply similar datasets and models to air quality concerns in their communities.

<http://airquality.gsfc.nasa.gov/>

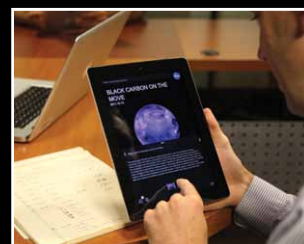
<http://water.gsfc.nasa.gov/>



A training participant works through a hands-on case study using NASA Earth observing data in Google Earth.



Applied Sciences gives presentations and trainings at NASA exhibits during symposia and conferences to inform audiences on uses of Earth observations.



The NASA Visualization Explorer app allows users to easily interact with extraordinary images, video, and information about NASA's latest Earth science research.





Simulated Climate, Supercomputing Muscle

2011.07.12



IceBridge: Airborne Polar Exploration

2011.06.02



Star Power - NASA Sees the Sun in Stereo

2011.06.02



Plant Growth and Global Warming

2011.06.02



Infinite Loop: Water on Earth

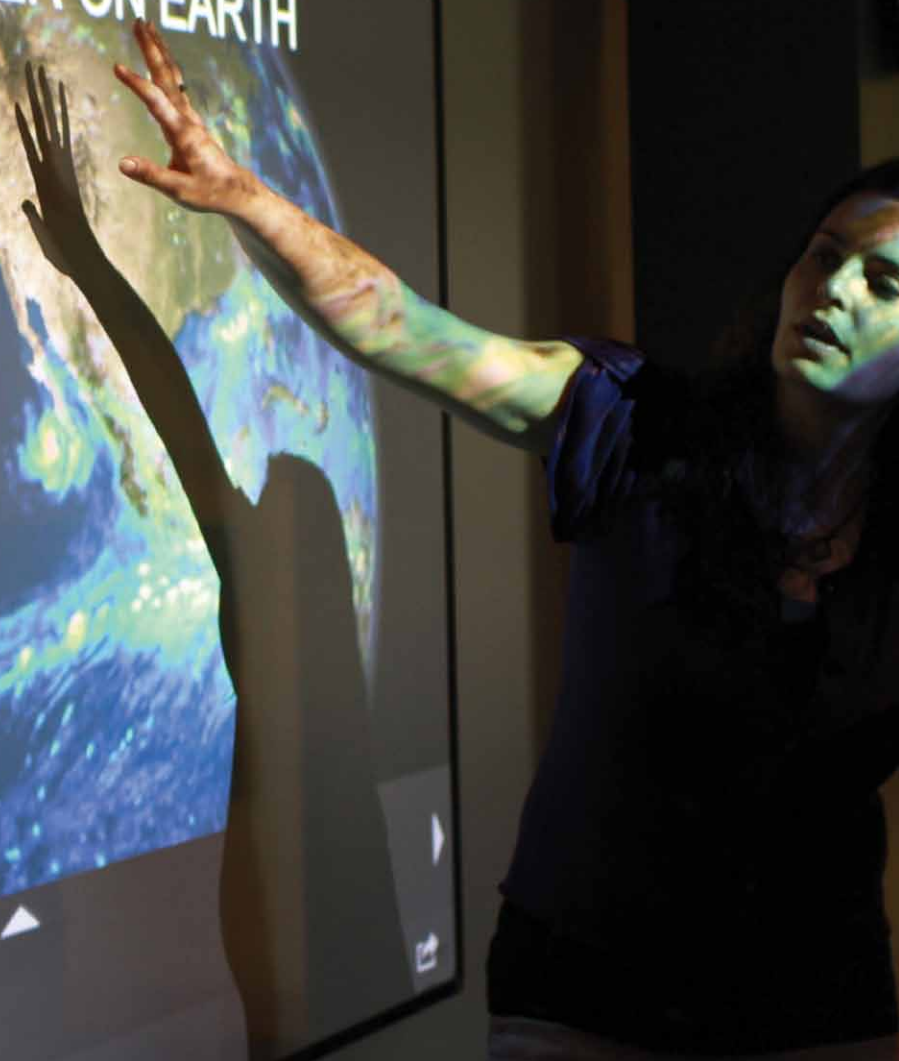
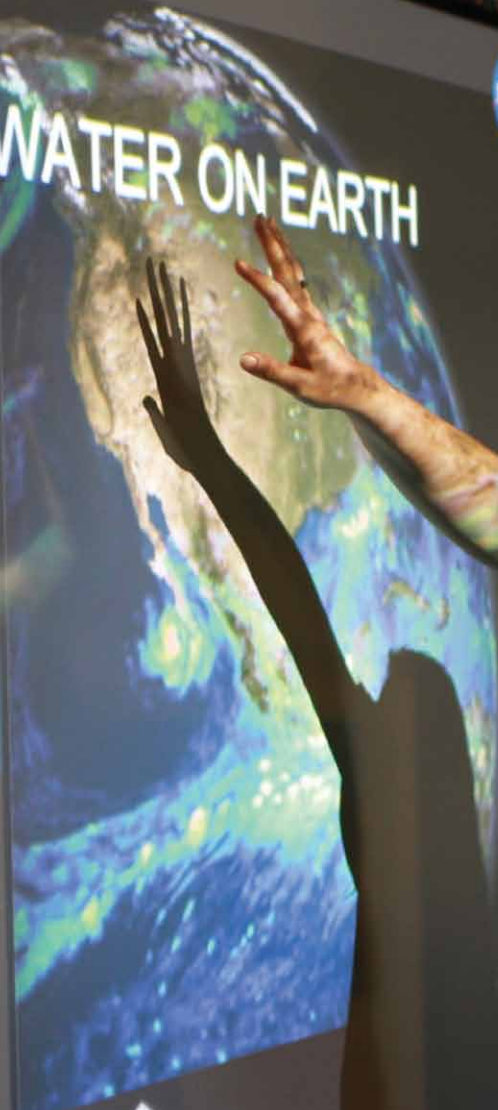
2011.06.02



Towers in the Tempest

2011.06.02

# WATER ON EARTH





## Applications Readiness Levels

Applied Sciences uses a nine-stage Applications Readiness Level (ARL) index to track the progress and maturity of applications projects—from the initial idea, through stages of development, to the transition and routine use. In the index, ARL 1 represents basic research and ARL 9 represents the operational deployment and sustained use of the Earth observations in organizations' decision making.

The ARL index provides a scale for Applied Sciences program managers to convey the expected advancement of applications projects and to assess the actual progress of a project. Project teams can use the ARL to establish and articulate key project milestones.

Applied Sciences uses data on projects' ARL progressions to conduct analyses on the difficulty of discrete stages in application development efforts. These analyses help identify factors that inhibit progress. The Program can devote additional attention to especially difficult stages and design interventions to increase the likelihood of successful projects.

### Applying Earth Observations in Energy Load Forecasting

In the energy sector, electricity demand is referred to as the "load." Utility companies use load forecasts to anticipate energy demands and to plan for the purchase of gas and electricity, gas storage, and electricity production. An Applied Sciences project applied Earth observations to improve the accuracy of load forecast models. More accurate load forecasts can help utility companies meet demand more efficiently and save utilities and consumers energy and money.

The project began at ARL 2. Following the completion of its historical analysis and the beginning of operational testing, the project reached ARL 5. The project conducted detailed statistical analyses and demonstrations in utility planning decisions. The project concluded at ARL 7 with the delivery of tools and documentation to support the adoption of the application by the utilities and weather forecast providers.

#### ARL Levels 7-9

Complete the integration and transition of use of Earth science products for sustained use.

#### ARL Levels 4-6

Develop and prototype capability of Earth science product to enhance decision making.

#### ARL Levels 1-3

Establish the information content, characterize decision support need, and assess proof of concept of application idea.

ARL 9  
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ARL 8  
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ARL 7  
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ARL 6  
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ARL 5  
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ARL 4  
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ARL 3  
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ARL 2  
—  
ARL 1







# Satellite Mission Planning

Existing and past satellite missions have demonstrated the value of Earth observations to end users, and organizations have applied data with increasing sophistication. In preparing for future Earth-observing satellites, NASA encourages end users to become involved in satellite mission planning from early stages and to stay involved throughout the life cycle. By doing so, they can anticipate potential applications, support mission design, be prepared to use the data soon after launch, and provide feedback on the data products.

For new and upcoming NASA Earth science satellites, Applied Sciences engages end users and the satellite mission teams to examine applications aspects and opportunities for the missions. The Program supports studies to inform design trade-offs and identify ways to increase the application value of the satellites. The teams hold applications workshops and mission-definition meetings to engage audiences interested in the satellite missions.

## Enabling Early Adopters of Satellite Data

The upcoming *Soil Moisture Active Passive (SMAP)* satellite mission will map global soil moisture and its freeze/thaw state from space. These measurements support analyses on trends in water availability and whether there will be more or less water regionally compared to today. The data can support improved flood prediction, drought monitoring, weather forecasting, wildfire risk assessment, and food security. Overall, the *SMAP* mission has both high science value and high applications value.

*SMAP* has held annual applications workshops and issued an applications plan, enhancing the value of the satellite mission to serve societal needs. *SMAP* created an Early Adopters program for organizations that have clearly defined uses for *SMAP*-like data products. Early Adopters receive simulated *SMAP* data products to evaluate and demonstrate the utility of *SMAP* for their particular decision-making activities. Early Adopters are expected to provide feedback on data products to increase *SMAP*'s application value and streamline uses of *SMAP* data soon after launch. Eighteen organizations have agreed to be *SMAP* Early Adopters, including USGS, Environment Canada, and the U.S. Department of Agriculture's Foreign Agricultural Service.

<http://smap.jpl.nasa.gov/>



image credit: NASA

*Landsat 8* will provide visible and infrared images of Earth's surface, supporting widespread uses for land-use planning, disaster response, agriculture, and water management.



image credit: NASA

*GPM* is an international collaboration to provide next-generation global observations of rain and snow, aiding research on global water cycling and forecasts of extreme events.

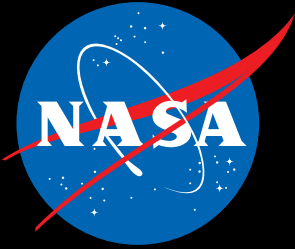


image credit: NASA

*OCO-2* will measure global geographic distribution of human and natural carbon dioxide sources and sinks, observing their changes over time.







## Get Involved

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How can you apply Earth observations to benefit your organization? Want to know more about how Earth observations can support decision-making? Do you have an idea for a workshop to examine uses of Earth observations in your field?

The Applied Sciences Program can help answer these questions and more. Applied Sciences funds feasibility studies, applications projects, and workshops to assist organizations in applying Earth observations in their management, business, and policy decisions. The Program seeks to increase the benefits of NASA's Earth science investments for society.

NASA Earth observations—including data, imagery, and tools—are free and available to the public. Visit <http://earthdata.nasa.gov> to access data gathered by satellites, aircraft, and field measurements to incorporate into your project and decision-making. All people and organizations across all levels of experience with Earth observing data are welcome.

Check the Solicitations section of the Applied Sciences Web site for information on funding opportunities and the News section for workshops, training opportunities, and project results.

Here are just a few ways you can become involved:

- *Propose and lead a feasibility study or application project.*
- *Attend or host a training event.*
- *Learn about projects your organization might adopt or adapt for your needs.*
- *Request funds for a workshop or symposium.*
- *Serve as a DEVELOP adviser or sponsor a DEVELOP intern.*
- *Give feedback on NASA Earth science data products.*
- *Participate on a project review panel.*
- *Attend Earth science team meetings to learn about research-applications connections.*
- *Meet and talk with the Capacity Building and Applications Areas program managers.*

### More Information

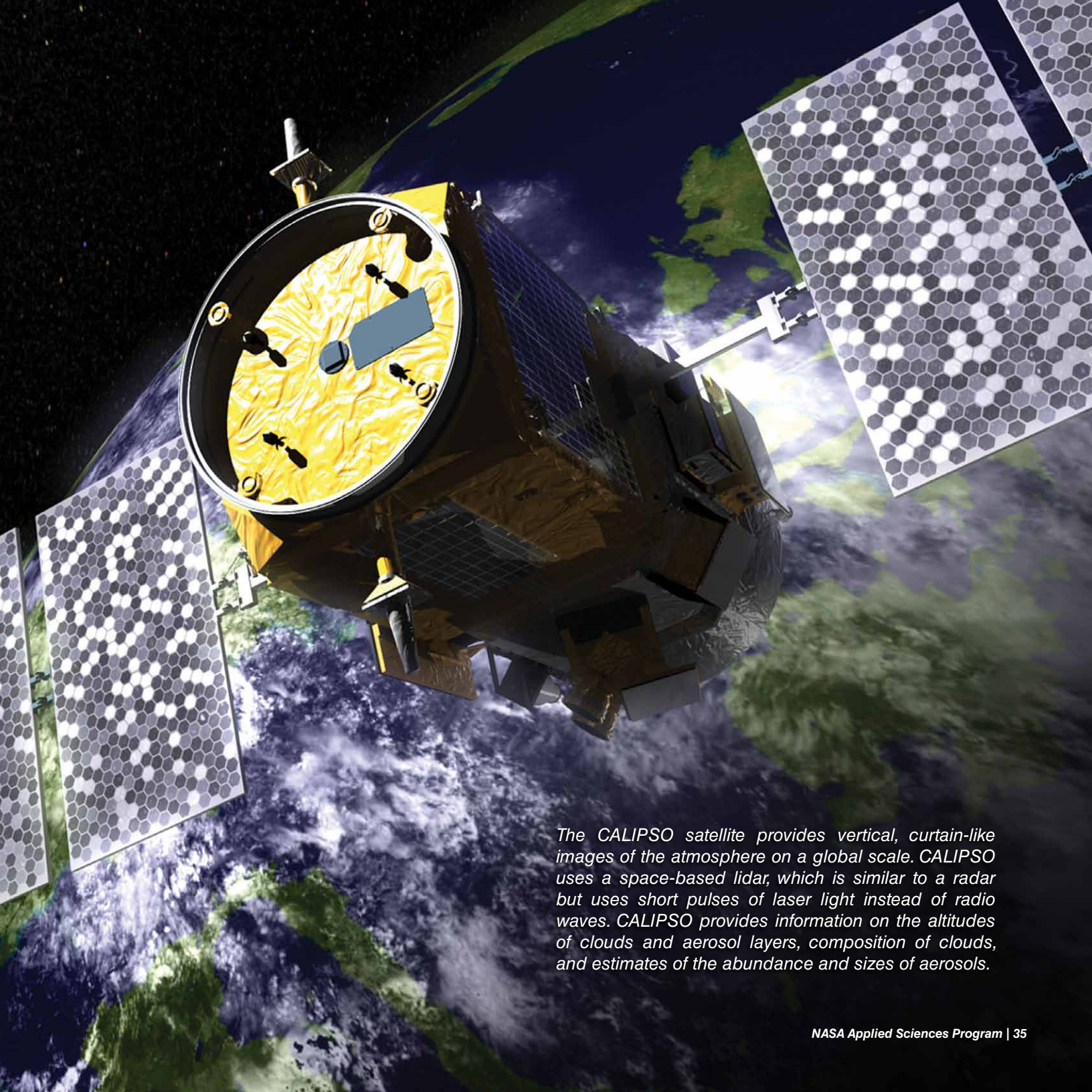
NASA Applied Sciences Program: <http://appliedsciences.nasa.gov>

Applied Sciences' Solicitations: <http://appliedsciences.nasa.gov/solicitations.html>

Applied Sciences' E-mail Address: [HQ-AppliedSciences@mail.nasa.gov](mailto:HQ-AppliedSciences@mail.nasa.gov)

NASA Earth Science Satellites: <http://nasascience.nasa.gov/earth-science/missions/>





*The CALIPSO satellite provides vertical, curtain-like images of the atmosphere on a global scale. CALIPSO uses a space-based lidar, which is similar to a radar but uses short pulses of laser light instead of radio waves. CALIPSO provides information on the altitudes of clouds and aerosol layers, composition of clouds, and estimates of the abundance and sizes of aerosols.*

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